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the cover

The outside and the inside of some of the research conducted in the field of biology at Georgia Tech. In the lower picture, Dr. Fetner and graduate nuclear science class view cellular changes on TV screen.

Cover by Van Toole and Harley Ferguson. Other photographs by Van Toole and Dr. David C. Ekey.

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The President's Page

UNTIL RECENTLY, it has not seemed logical or necessary for certain medical sciences to merge with physical sciences toward a common goal.

Yet, within the walls of Georgia Tech's Bioengineering and Radioisotopes Building there are biologists, sanitary engineers, radiation biologists, bacteriologists, and bio-physicists all working in the broad field of biology. Projects dealing with simulated operating rooms, x-rays, and bacteria are now active. There, Tech researchers together with doctors at Emory University many times investigate modern medical problems.

All medical-oriented research at Georgia Tech is not to be found in the bioengineering laboratories. It is also conducted in the X-ray Diffraction Laboratory in the main research building of the Engineering Experiment Station. Here turkey tendons and gall stones have been investigated using the principles of crystallography.

In the department of Industrial Engineering, cooperative projects have taken place between the medical profession and industrial engineers. Efficient use of hospital disposables and the use of medical techniques for industry's fatigue problems are current projects.

With the approach of a possible common ground for all sciences, Georgia Tech's curriculum of education and research is not to be left behind. Tech will continue as in the past to be a leader in seeking and passing on knowledge of our world.

E. D. Harrison *President*

This researcher is preparing samplers to be used in studying

THE "STAPH" PROBLEM

by

Thomas W. Kethley
William B. Cown
Edward L. Fincher

The first year of the three year-study of the ventilation effect upon bacterial load of air in simulated hospital operating rooms has been completed. The ultimate objective is to define the role of ventilation in air hygiene and to obtain maximum benefit from the use of ventilation in reducing possible transmission of infectious material within the operating room. This study is concerned with contamination sources within the operating room—dust, clothing, and the doctors and nurses themselves. The most notable offender in hospital incurred infections today is *Staphylococcus aureus,* a common bacterium which obtains its name from its characteristic growth in grape-like clusters (*Staphylococcus*) of small round berry-like microorganisms (Staphylococcus) and the fact that when grown in masses, called colonies, these colonies have a bright golden color (*aureus*). Referred to as staph, this bacteriam has a day-to-day working arrangement with man. Practically every person from infancy has staph on his skin, and quite often harbors them in their nasal passages and sometimes in their intestines, without either the person or the staph suffering from the relationship. However, occasionally something happens to upset this fine balance and the microorganism does harm because there has been some change in the defenses of the person or some change in the staph itself. The most common awareness of the presence of staph on our bodies occurs when one has an infected pore (pimple). Much more serious are those situations where the staph have somehow penetrated the body's defenses to effect a successful invasion of the living part covering the bones of the body, causing osteomyelitis.

This ability of the staph to cause various infections is characteristic. For example, the TB microorganism causes a definite disease; namely, tuberculosis. On the other hand, the staph microorganism causes no single

specific disease, but a variety of infections, so that one speaks of staph infections rather than a staph disease.

It should be evident that weakened hospitalized individuals, or the newborn infant, are all especially susceptible to staph infections. The real puzzle is why under these conditions do such a relatively small number of these infections occur? The answer—the ability of the host to handle the infection and the nature of the infectious agent.

It appears that the most dangerous outbreaks of staph infections are due to the emergence of new and more vicious forms. These new staph are more capable of penetrating the body defenses, initiating an infection, causing a more serious infection, or are more resistant to treatment. That these new staph are resistant to treatment is one of the reasons behind the need for the ventilation study in hospital operating rooms. A patient in surgery is in a weakened condition, and despite the most stringent care, the surgical wound must be exposed to the air, sometimes for hours. If staph somehow enter this wound, there is the possibility of an infection ensuing, often in a site dangerous to the welfare of the patient.

Such conditions were observed prior to the routine use of antibiotic drugs. However, after the introduction of antibiotics, it was felt that this danger no longer existed, because staph are ordinarily easily controlled when antibiotic therapy is instituted. Unfortunately, there have emerged several strains of staph which are resistant to antibiotic therapy. The situation exists then where a patient may incur a staph infection during the course of surgery. This infection may still threaten his life or add days or weeks to the period of hospitalization even now after the advent of antibiotics.

Every rational effort is being made to eliminate the causes of staph infections and to control the routes of

RESEARCHER RECORDS DATA TO DETERMINE VENTILATION RATES.

transfer of these microorganisms in the hospital operating room. There is greatly increased emphasis upon rigorous aseptic techniques, the use of sterile clothing, the use of more effective masks, the searching out of personnel who might harbor and spread particularly vicious strains of staph, the evaluation of ultra-violet radiation before and during operations, careful scheduling of operations so that those involving infected patients do not precede those involving non-infected patients, the careful screening and, if possible, the isolation of patients with staph infections, the control of dust, and examination of the possible role of the aerial route in the spread of staph infections. Georgia Tech's study concerns the examination of the part the aerial route plays in the spread of staph infections.

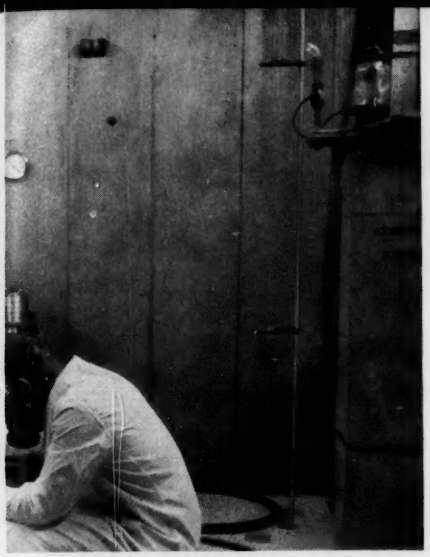
In the study, it is considered that clean air only enters the room; the source of contamination being within the room. Further, the aerial route is considered to include any transmission not involving direct contact, and involves a consideration of droplet transport and large particles, as well as those fine particles which are freely airborne over large distances. It is considered possible that staph-infected material, in the form of small particles or droplets, can be transferred from the clothing or persons of the doctors or nurses within the operating room to the wound site, thus initiating an infectious process. To achieve the study's purpose, a simulated operating room has been constructed in the Aerobiology Laboratory within the Radioisotopes and Bioengineering Building of the Georgia Tech Engineering Experiment Station.

Sampling for moving air-borne bacteria in

THE RESEARCH PLAN

The variables to be studied in this project are ventilation pattern, employing both standard and non-standard procedures, ventilation rates, from 10 to 30 changes per hour, and position of the source of airborne bacteria within the room, at several levels. The ventilation pattern refers to the method of introducing or removing air from the room; ventilation rates refer to the relative volume of air introduced into the room over a period of one hour.

In order to evaluate these variables the following determinations are being made: (1) estimation of rate of turnover from the volumes of air handled; (2) determination of the rate of turnover with helium gas and thermal conductivity equipment in terms of rate of disappearance of the helium gas from the room while the room is ventilated; (3) the linear velocity and direction of flow of the air currents within room during ventilation; (4) the exact concentration, from a standardized bacterial aerosol, of the bacterial



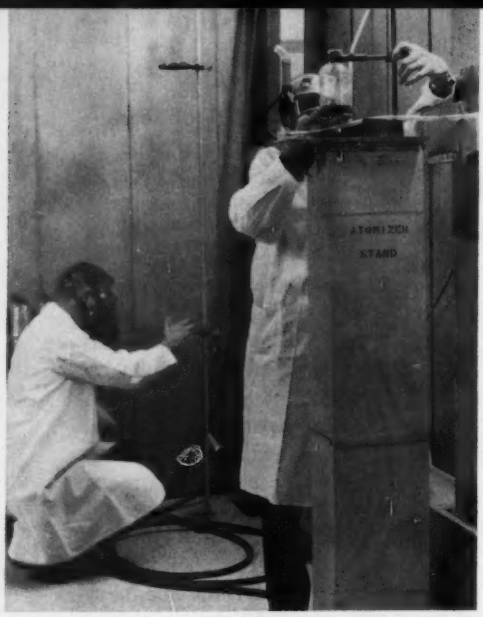
Bio-engineering's Simulated Operating Room

particles throughout the room, when ventilated; (5) the exact number of bacteria settled at various locations throughout the room; (6) the size of the airborne bacterial particles; (7) determination of the rate of turn-over with aerial bacterial samples taken after the shut-off of the source of bacterial contamination.

These determinations are made for each set of ventilation procedures. Employing a standardized aerosol of known output of bacterial particles per minute, it is possible to relate, quantitatively, the effectiveness of ventilation patterns in reducing the bacterial load of the air in the simulated operating room, and to relate this effectiveness to the physical factors of rate of turn-over, air currents and distribution of air within the room. Results will indicate the relative effectiveness of standard ventilation procedures and yield basic information for better procedures strictly in terms of the bacterial load of the air within the operating room.

THE SIMULATED OPERATING ROOM

The inside dimensions of the operating room are approximately 12′ x 16′, 10′ high having an internal volume of almost exactly 1800 cubic feet. This room and all of the experimental equipment are located within the Aerobiology Workroom, completely equipped with laboratory facilities and having its own separate ventilation system for the maintenance of desired temperatures and humidities. For most of the study 75° F. and 55 per cent relative humidity is employed, the air conditioning equipment having sufficient capacity to overcome the heat of the 4,000 watts of lighting used in an operating room. The operating room is constructed of unitized, self-supporting galvanized sheet metal sections and sealed air-tight with an inert sealant. It is also provided with a gasketed door which provides an air-tight seal when locked closed. Entrance into the room is through a ventilated anteroom, approximately 5′x4′, 10′ tall. In order to ventilate the operating room under positive pressure and at the same time insure personnel safety, air is forced into the room with one set of blowers and extracted from it with another set. The outlet blowers extract air from the room at the same rate at which it is forced in, withdrawing the air through ultra filters to remove bacterial particles. The extracted air is then vented to the out-of-doors. Air from the anteroom is treated in a similar manner. The anteroom is ventilated at 100 changes per hour to prevent the escape of contamination from the operating room when the operating room door is opened.



THIS ATOMIZER DUPLICATES HUMAN'S COUGHS IN OPERATING ROOM.

The Staph Problem - Cont.

For safety, there are only four air entry ways into the operating room, two employed for entrance air and two for exit air, each being ducted to individual blowers outside the operating room. These blowers are equipped with aileron controls for exact balancing of the air flow. Within the room, ducting has been provided with which a large number of ventilation procedures can be applied. The entering ducts can be connected into a single large, flat, ceiling duct to which diffusers can be connected or sub-ducting connected in order to introduce air into the room in any other manner desired. The exit ducts are located at the corners of the room and sub-ducting is available for the extraction of the air from any desired position within the operating room.

A commercially available glass atomizer produces the bacterial aerosol which constitutes the experimental contamination of the operating room air. A suspension of bacteria of known concentration is atomized with carefully regulated air to produce a standard contamination, either at the five-foot level (to simulate talking), or at the two-foot level (to simulate shedding from clothing or disturbances of dust particles).

SAMPLING THE AIR

The operating room is divided into equal areas of two foot radius for sampling, yielding a total of twelve sampling stations. At each station, sampling for bacterial aerosols is carried out at four positions; the floor, 2′, 40″ and 7′ above the floor, making a total of forty-eight sampling positions. The sampling stations are also employed in the determination of ventilation rates through the use of gases. Air currents are measured at all the stations at the 1′, 2′, 40″, 7′ and 9′ levels.

The aerial concentration and particle size of the bacterial particles are determined with the so-called Andersen sampler. Air is drawn through this sampler at 1.0 cfm, the particles being impacted upon agar plates within the instrument. The larger particles are collected on the top plates and the smallest on the bottom plate. An estimate of the particle size can be obtained in terms of the plate upon which the particles collect. The agar plates are incubated for twenty-four hours, the colonies counted, and the results expressed as numbers per cubic foot of air sampled.

COLONIES FROM THE COLLECTED AIR-BORNE BACTERIA ARE COUNTED.

Settling plates are simply dishes containing agar, exposed for a definite period of time, during which the larger airborne particles are deposited upon their surfaces. Following incubation these colonies are counted and the results expressed as numbers settling per square foot per minute.

Personnel who enter the room to take samples wear respirators for their protection.

HANDLING THE DATA

For each ventilation procedure and various rates of turn-over, data for air currents and for aerial and settling concentrations of bacteria are plotted on a series of modified prospective sections of the room which show the relative levels of air currents and bacteria throughout the room. These plots are examined for concentration gradients and these are noted in relation to air flow patterns and in relation to the location of the source of bacterial aerosol. The lows, highs and overall average concentrations are recorded for comparison with those from other ventilation procedures and other rates of ventilation. This procedure is followed for total aerial concentration, particle size and settled particles. Particular emphasis is given to the distribution of the larger particles throughout the room, it being believed that these represent the greatest potential danger. The estimated rate of turnover is compared to that determined from the helium gas die-away and that from the die-away of the airborne bacterial particles.

RESULTS OF STUDIES TO DATE

Thus far, an intensive study has been made of the simplest type of ventilation procedure, namely intro-

ducing the air into the room through two entrances in the end wall, located near the ceiling, and withdrawing the air from the room through two exits in this same wall, each located at a corner, near the floor. A brief description of the results of this study follows. Pattern of air currents.

For 10, 20, or 30 changes per hour the same general pattern is observed, namely, the formation of a vortex in the center of the room, the air passing along the ceiling, striking the far wall, and passing along the floor and then upwards. At 10 changes per hour the air currents do not turn upward until they have passed along the floor almost to the end from which the air entered the room, making a single large vortex pattern for the room. At 20 and 30 changes the air also turns upward from the floor more nearly at the mid point of the room, and thus forms at least two vortex patterns, one encompassing the entire room, and another encompassing the half of the room most distant from the entering point of the air.

Linear velocities above 20 fpm were encountered throughout the room at 10, 20, and 30 changes per hour; the floor velocities being about 75 fpm at 10 changes, and up to 175 fpm at 30 changes per hour. It is self-evident that none of these conditions meet the requirements of the most elementary standards for ventilation.

DISTRIBUTION OF BACTERIAL PARTICLES

With the aerosol source located within the room three types of bacterial particles were employed; a monodisperse aerosol about 2.0 micron diameter, a fairly uniform aerosol about 5.0 microns diameter and a disperse aerosol having a medium size of about 10 microns diameter, containing particles 50 micron or greater in diameter. In general, the particles 5.0 microns or less in size were distributed uniformly throughout the room, although somewhat higher concentrations were observed near the aerosol source. The larger particles were freely transported throughout the room, but showed considerable stratification, the strata emanating from the aerosol source and following the air currents around the room. For the larger particles the position of aerosol source within the room did make a difference, the greater concentration being near the aerosol source, but in no instance did any part of the room show much less than 50 per cent of overall average concentration exhibited throughout the room.

FUTURE WORK

Various commercially available air diffusers will be evaluated. Manufacturers of typical equipment have been requested to submit lay-out plans for the optimum utilization of their equipment in the hospital operating room. At the completion of the study information will be available for the formulation of recommendations as to the commercial equipment most suited for the hygienic ventilation of an operating room, and for the possible design of special ventilating equipment for this particular purpose.

ACKNOWLEDGMENT

This study is supported in part by a grant from the National Institute of Allergy and Infectious Diseases of the National Institutes of Health, United States Public Health Service.

FROM CELL to MAN

by

Dr. R. Fetner

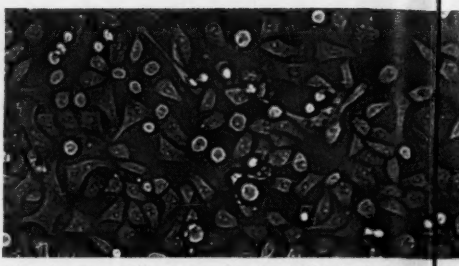
Man is a cellular being. He begins life as a single microscopic cell and reaches his full magnificence by numerous multiplications of this basic unit. Even as an adult he is dependent upon the continuous production of new cells for replacement and maintenance. The process by which cells duplicate, and the basis for all growth, is of fundamental importance to man in an understanding of himself. The study of cells is exceedingly difficult as is even a discussion of some of the problems. An analogy cannot be made with inanimate systems because nothing else in nature is so complex. Life stands at a level of comprehension where knowledge of the phenomena may have limited application. The process of cell division is an example. Each cell produced from the initial cell must contain all of the information developed through eons of time and must pass it along cell by cell to future generations. This is apparently accomplished by somehow storing these data in small units localized on rod-like bodies called chromosomes within the nucleus of each cell. If this information is to be transmitted intact during cell multiplication it must be duplicated with finite precision. To interrupt or interfere with the process will have profound effects. The study of cell multiplication or *mitosis* is fundamental to an understanding of life itself.

The progression of a cell through division is a function of physio-chemical processes acting within genetically determined parameters. It is not a random process. If there are no factors in the environment which become limiting, the various stages of mitosis are predictable and the process provides an exquisitely sensitive as well as fundamentally significant test process. Most of our knowledge about typical life processes has been obtained by studying a typical variation. We have learned of the normal by studying the abnormal. Experimentally provided alterations in mitosis apparently

offer the best method of learning more about the basic process itself.

Studies are being conducted on the effects of various agents on cell multiplication. Ozone is one material of interest, because it has the capacity to produce changes without harming. Such materials are called "mutagens" and are of particular interest. The killing of a few cells most often has little significance because it is a terminal process. The alteration of cellular activity however may have continuing profound influence particularly if the "information centers" have been affected. Ozone exposure produces specific effects upon cells and their multiplication which are similar in some respects to those produced by high energy irradiation. This is not unexpected because ozone decomposition products in water are identical to those produced by high energy irradiation. However, there are also some differences which are perhaps more important because they indicate that part of the irradiation effect on cells is due to other causes. Since ozone exists as an industrial air pollutant and a natural layer at high altitude it has more immediate interest. Quantitation of the effect may help to determine exposure limits and to interpret effects in man. Work in this area has been supported by the National Institutes of Health and the School of Aviation Medicine of the U. S. A. F.

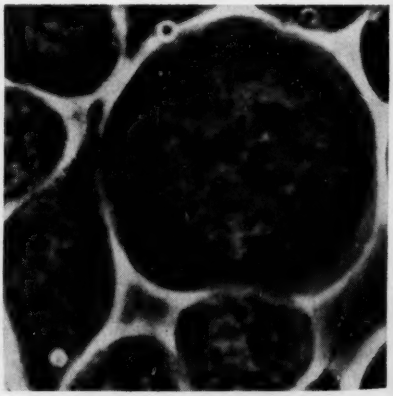
In addition to investigating the cell division process, studies are underway on the physical carriers of genetic information—or chromosomes. Here again one learns of the normal by studying the abnormal. The selective activity of various agents against the

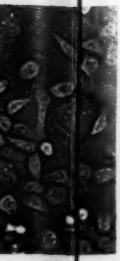


Live human cells approximate .0004 inch in dia

Chro

A living embryonic cell photographed and magnified 1500 times under a microscope.





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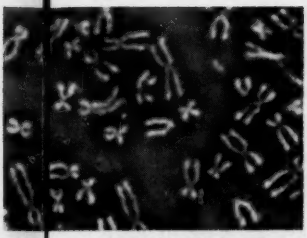


Chromosones; .00008 inches long

Human chromosone with an ozone-induced break in one of its arms is pictured above.

chromosomes, their capacity to wreck the threads of various sites, may provide an insight about how these structures are made. High energy radiation, for example, breaks the chromosome fibers randomly, while certain chemical agents are specific for various sites. When such information is more complete a better understanding of the forces which bind these structures will be known.

TEST TUBE LIFE

Human life in a test tube? It is now routine in many laboratories all over the world; not the generation of life, to be sure, but the maintenance of human cells in culture in test tubes. Such cells may be maintained indefinitely and under ideal conditions will double their numbers approximately every 30 hours. The importance of such experimental material is obvious. Georgia Tech has been active in developing methods for toxicity evaluations using human cells in culture as a test material. All of this work is in its infancy. Only in the last two or three years, for example, has the chromosome number of man been definitely established. In conjunction with the Department of Radiology at Emory University a study is being conducted to compare the biological 250 KV X-ray and CO^{60} gamma radiation at various depths in water. The effects produced by chromosome breakage and cell survival in human cell cultures is being used as a criteria of effectiveness. Present medical dosimetry is based upon physical measurements, mostly ionization. A biological dosimeter, particularly human cells, may give a more realistic measure of radiation effectiveness.

Molecular Modifiers

by

Dr. N. Williams-Walls

The nature of the biochemical injury produced by radiation is still an unknown in a field where our lack of knowledge far outweighs the facts we have thus far collected. What chain of events is touched off by a lethal dose of radiation? Is each step dependent upon a preceding alteration in the normal metabolic (chemical process) pattern of an organism (living substance) or do a number of different types of damage occur which though independent in origin, later combine to produce the final deadly effect?

This problem, along with many others, has interested research workers for many years. The search for its solution has become more urgent since radiation is a real health hazard in the atomic age.

Bacteria are being used as test organisms to determine what factors will alter their protection from radiation damage by an enzyme, catalase which by definition does not react itself but does effect the reaction. This enzyme is normally present in the cells of all higher animals. It has already been demonstrated that it significantly reduces death of certain bacteria when it is present during their irradiation. Now different types of bacterial cells are being tested: cells that require oxygen in order to grow and multiply, cells that will grow only if oxygen is completely *absent* from their environment, cells that have catalase in them as part of their biological makeup and cells that lack this enzyme, and, finally, cells that are more resistant than usual to all forms of physical and chemical attack because of a thick protective coat. These last cells are bacterial spores which are inactive cells inside normal vegetative cells. The results obtained will be studied to see if a pattern of survival, dependent upon these factors, has been established.

Other physical factors which are to be varied in this study will be the concentration of catalase present during irradiation and the temperature of the solution in which the bacteria will be suspended.

A number of pieces of equipment have been or will be purchased for the pursuance of this project. At present a large refrigerated centrifuge is being employed in the collection and cleaning of the bacterial cells for use in experiments after their growth. This centrifuge will maintain a constant

PREPARING . . .

. . . BACTERIAL SPORES . . .

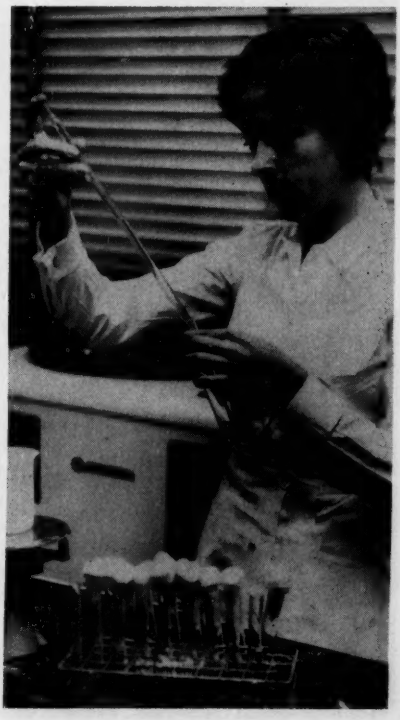
. . . TITRATING

temperature during operation. It is being operated at present at +5° C but it is capable of holding temperatures as low as —20° C for indefinite periods of time.

Electrophoretic and Warburg studies are to be performed. Electrophoresis is the separation of different components of a compound by the use of an electric current. Since materials of different molecular weights or different electrical charge travel at different rates of speed in an electric current, it is possible to do the aforementioned separation. A Warburg apparatus measures the changing respiration rate of organisms and with its use it is possible to detect the effect on the respiration of the bacteria of irradiation and the different physical conditions being studied.

The work being done on the present research project is designed to contribute to the ever-growing body of information which will someday give us the answer to the mechanism of damage and death of an organism exposed to radiation.

These research studies are supported totally by National Health Institutes.



"Pulse Normal—Blood Pressure High, Dr. I. E."

by Dr. David C. Ekey

In industry wage incentives, job evaluation, methods, and personnel selection are functions of the Industrial Engineer which require evaluation of human energy expended. Use of human energy in industry requires decisions relative to man's capacity for work, proper remuneration for physical effort, and optimization of the work schedule to minimize fatigue and increase productivity.

The continuing pursuit of the problem of measuring energy expended has resulted in five methods. These methods are used by engineers and psychologists in industry today.

PIECE WORK SYSTEM

This system attempts to reward additional effort, expended beyond the normal performance of a "fair day's work." Evaluation of normal energy requirements is usually based on experience of the Industrial Engineer and "rule of thumb." This quantity of production per unit of time is widely used for determining the proper reward for muscle power.

FATIGUE MEASUREMENT

For jobs resulting in a high degree of physical exhaustion, the quantity of work over a period of time is used to construct a fatigue curve. The fatigue curve provides a rough measure of energy expended when the job is exhaustive in nature. Unfortunately, for those supporters of this technique, most of the jobs in industry do not require such high level energy expenditures. Under conditions of normal physical effort, the fatigue curve is not a good index of energy expended.

PHYSIOLOGICAL SYSTEM

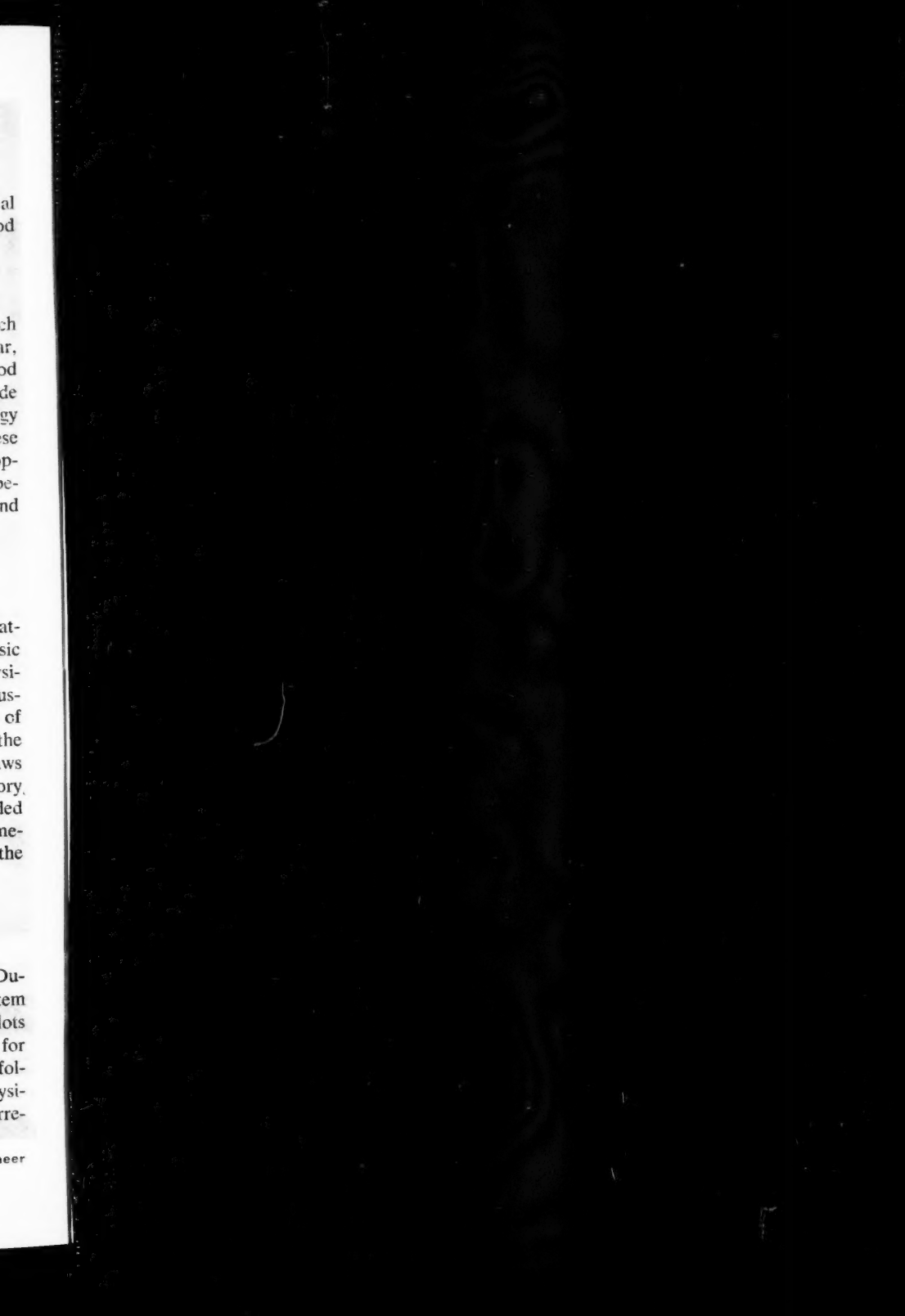
Physiological measurements such as basal metabolism, blood sugar, blood lactic acid, pulse rate, and blood pressure have been used to provide valuable information on energy requirements for certain jobs. These techniques have not proven to be operational for industrial applications because of the complex equipment and methods involved.

MECHANICAL-PHYSICAL SYSTEM

In mechanical-physical system, attempts are made to apply the basic laws of mechanics to measure physical effort. Since a majority of industrial tasks involve the transporting of loads where energy expended is in the form of static work support, the laws of mechanics do not give a satisfactory measure. Physical energy is expended in holding a load even though no mechanical work is performed until the load is moved.

HEART-RATE-RECOVERY SYSTEM

Developed by L. B. Brouha of DuPont, the Heart-Rate-Recovery system is the most recent. Dr. Brouha plots the recovery rate of the heart beat for a three minute period immediately following the performance of some physical task. He has been able to corre-



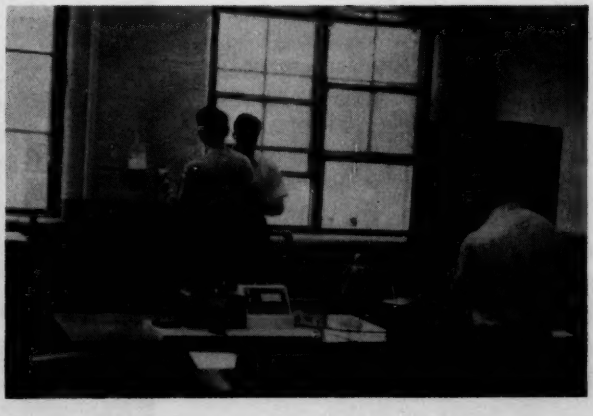
After exercise, this subject's blood pressure is measured.

late the rate and level of heart beat recovery to energy costs. This system is one of the most promising methods developed to date for operational use in industry.

Georgia Tech's Fatigue laboratory is being used for basic research graduate work at MS and PhD levels in developing further knowledge relative to the measurement of human energy and to study the effect of variables related to human energy expended in typical industrial environments.

At present its School of Industrial Engineering has purchased electronic pickup and recording equipment to study various random variables related to the heart beat, heart-sound waves, respiration and body temperature. The objective is to determine a valid and operational measure of human energy.

Two research projects have been completed; one concerned the energy-measurement phase under "nominal exercise" and the other under "violent exercise."



While using upper body muscles on torsion bar, the galvanic skin response, the heart sound, the heart rate, and blood pressure are simultaneously recorded.

Simultaneous recordings are taking place while the lower body muscles are exercised.

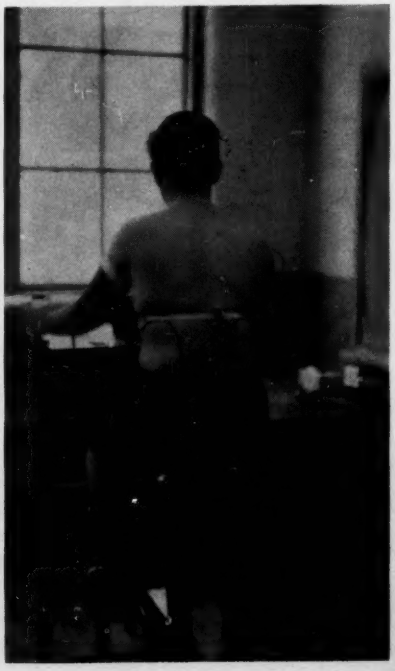
The laboratory is unique in the field of Industrial Engineering and will be a pioneering effort. Ultimately, the facility will have a "black box" in which the variables of human energy can be continuously monitored while the environmental variables of humidity, temperature, lighting, color, noise, air velocity, and work load are accurately controlled.

The major research being done can be conveniently divided into two areas: one of measuring human energy, and the other of studying the influence of work environment on human energy requirements.

In the study of human energy, we are investigating the frequency and amplitude of certain variables related to the heart. Specifically the variables of heart pulse wave, average heart-sound wave, rate of the heart beat, respiration, and electrical potentials of the muscles. Electrocardiograms will also be recorded as a control variable in evaluating the condition of a subject's heart. Equipment currently being used to study these variables are a 4-channel basic medical assembly, general purpose pre-amplifiers for use with above basic assembly, pulse wave attachment, pneumograph, average heart-sound-amplifier, power supply and microphone, cardiotachometer, strain gage pre-amplifier, electrical myograph, electronic body temperature recording instrument $\pm$ 1/100° accuracy.

Once a significant correlation is established between levels of work and the heart variable(s), it will be possible to study the influence of environ-

Operation of the proney-break hygrometer.



mental factors, types and duration of rest periods, work methods, and work task on human energy.

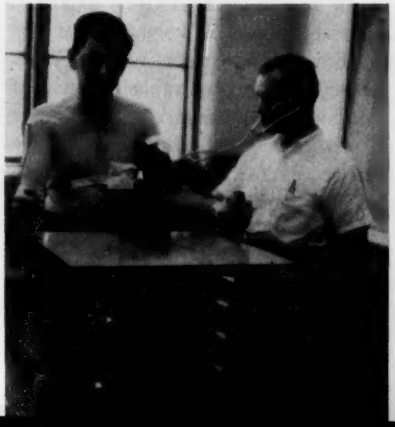
Long range research plans include the development of miniature transistorized broadcasting and pickup units to permit the recording of the physiological variable, and thus add greater flexibility in the research by eliminating the present lead wires. More advanced work tasks will also be developed. Also anticipated electronic summers will eventually augment the tape recorders so that the heart variable can be integrated. A meter effect will measure the human energy component of a worker over an extended period of time. Electronic filters will be used to give estimates of several statistical parameters describing the response curves.

At present there are many experimental results of interest. At extreme levels of physical work, "mild" and "violent" exercise, the work rate is more dependent upon the time variable rather than extremal adjustments in the actual work load.

Galvanic Skin Response, Heart Roto, Heart Sound, S-D blood pressure, the difference of systolic and diastolic, were found to be good indicators of physiological cost. While extensive research in the medical field shows no significant relation between systolic or diastolic blood pressure and work effort—it was found that the differential (S-D) was extremely significant, and that the variable (S-D) is a good "homogeneous predicator" of work effort among workers.

The operational set-up of the Torsion bar.

Note the white sound-proof plastic containing a microphone for heart-sound pick-up.



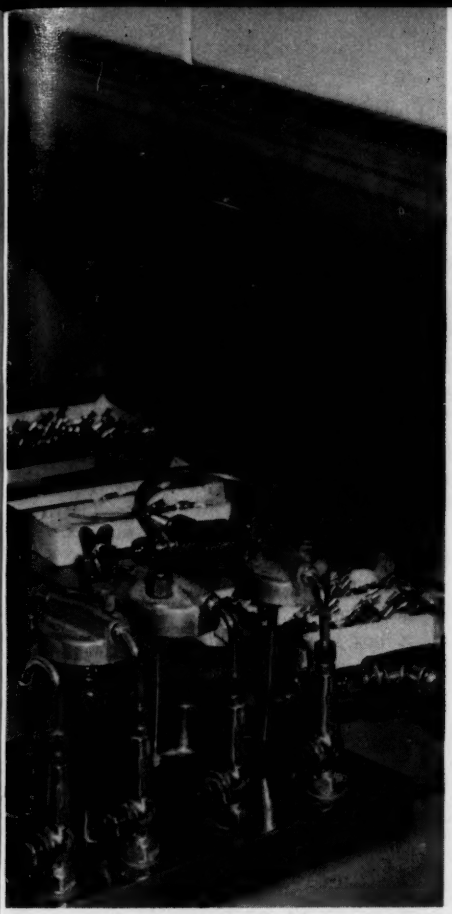
Fatigue studies by the Industrial Engineering Department are supported by Engineering Experiment Station of Georgia Tech.

To Buy or Not to Buy?

by
Dr. Harold E. Smalley

Increasingly, we are beginning to see pre-processed and disposable items of all sorts in our daily lives. Items such as disposable napkins, paper cups, facial tissues, foodstuff packaging, and other disposables have become commonplace. Part of the stimulus for this innovation has come from a consideration of convenience; to some extent, as a means of reducing labor costs. The economies characteristic of mass production are being effected by a substitution of specialized labor in the factory for diversified, highly skilled, and relatively expensive labor at the point of consumption.

The health services industry is beginning to use disposable items in increasing volume, e.g., disposable surgeon's gloves and disposable syringes and needles. Of course, other disposable items, such as napkins, cups, pads, and gauze have been used for some time. There is reason to suspect that



CLEANING, SHARPENING, STERILIZING OLD USED NEEDLES FOR REUSE

advantage can be gained in hospital operation through increased use of disposables without adversely affecting the quality of patient care or the quality of hospital services rendered. Indeed, it is likely that in some respects disposable items are superior to reprocessed items from a quality standpoint. Sterility, handling ease, and personal preference may prove to be distinct advantages of disposables. Unfortunately the quality attributes of any hospital item are difficult to appraise due to the lack of an adequate operational definition of *patient care*. The question of relative monetary costs is not nearly so perplexing, but it does require study. It is likely, but no one is quite sure, that at the present time disposables are more costly than conventional reprocessed items. Unfortunately, most hospitals do not have industrial engineers nor good cost accounting systems which could provide definitive cost information upon which the hospital administration can make objective decisions regarding the alternatives of disposable versus reprocessed items.

It is the overall purpose of this study to devise, test, and perfect a procedure for use by the hospital administration in making decisions with respect to these types of supply items. The development of a practical decision system will enable hospitals to use objective policy guides instead of tradition, bias, and hunch.

The specific aim of this project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals. This study constitutes the first phase of an investigation of decision alternatives and their relation to hospital supply costs.

The project is organized in the School of Industrial Engineering of Georgia Institute of Technology through the Engineering Experiment Station and is being conducted in cooperation with Emory University Medical Center and hospitals in the Atlanta area.

The study is being conducted by an

interdisciplinary research team that includes several industrial engineers, a registered nurse, a sociologist, several graduate research assistants, student assistants, and special consultants. Two other important resources are being utilized in this project. A Local Steering Committee, representing cooperating institutions, assist in identifying problem areas and provide liaison with hospitals in which studies are carried out. The National Advisory Committee consists of recognized authorities in the realm of this research area. These leaders bring to the project a wealth of experience and wisdom.

Disciplines represented by these two committees include business administration, economics, engineering, hospital administration, management, medicine, nursing, operations research, psychology, public administration, and sociology.

The approach toward the attainment of the overall objective of the research is the pursuit of a number of related projects, each under the responsibility of a project leader. In the paragraphs to follow the progress on each of these projects is related.

BIBLIOGRAPHY

The objective of the bibliography project was to make available ready references concerning disposable and reprocessed hospital supply items as well as important works concerning applications of industrial engineering to hospitals. Pertinent references were compiled and incorporated into a classification system. Two project bulletins have been published; these list all references compiled through 1959. The bibliography is being maintained by systematic additions. It is planned that supplemental bibliography bulletins will be issued annually for the life of the project.

CLASSIFICATION OF DISPOSABLE ITEMS

The objectives of this study were to determine which hospital supply items are generally available as disposable products, to classify these in some useful scheme, to determine which supply items deserve first consideration by the project, and to suggest which items or classes of items deserve to be included in final decision models. Results indicate that gloves, needles, and syringes should be studied first. A priority listing of other supply items has been compiled. This study has been completed and its results are serving as a guide in current studies.

INVENTORY POLICIES AND COSTS

Several specific studies have been done in the area of inventory policies and costs. One of these was a master's thesis entitled, "Development of an Inventory Model for Hospital Supplies." Another study, also a master's thesis, was entitled "Forecasting the Demand for Hospital Supply Items." A third study attempted to evaluate the practicability of the methods suggested in *Scientific Inventory Control* by W. Evert Welch. This study was carried out at Emory University Hospital by undergraduate students under the supervision of a faculty member in the School of Industrial Engineering.

Several preliminary studies were undertaken concerning decision rules for aggregate supply items and inventory policies with their resulting costs. A

study of demand distribution has been under way for several months, and this information is being tabulated for use in several phases of the overall project.

At the present time the inventory aspects of the project are being pursued under three separate studies: order costs, carrying costs, and collateral material.

METHODS CLASSIFICATION AND WORK MEASUREMENTS

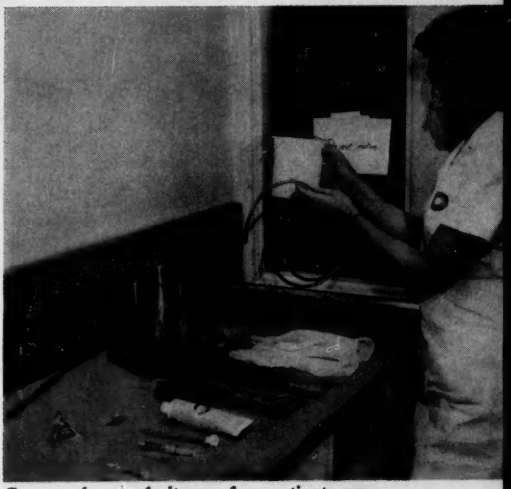
The objective of this project is to identify the methods used and the corresponding standard times to process and handle supply items. The supply functions are being described according to a system of classification. Descriptions of methods levels and time standards have been obtained for surgical gloves at seven hospitals.

Extensive data on work measurements are being compiled so as to approach the problem of work times and costs associated with supply items. This phase is concerned with a microscopic approach which hopefully will synthesize costs of processing and handling items in the hospital.

As a kind of replication of the work measurement approach, a work sampling study is being done to obtain various percentage allocations of work effort for different supply items in the central supply department of Emory University Hospital. A secondary purpose is to obtain normal times for performing various tasks associated with the different supply items.

HUMAN FACTORS

Various studies dealing with human factors and nonmonetary costs have been planned under the general supervision of the social psychologist consultant assisted by the nurse member of the research team. A major study relating to human factors is a study now in progress which is attempting to determine the factors, including direct costs, which influence or affect the preferences and decisions of those who are involved in supply decisions. This study also is attempting to determine the relative weight or importance which each organization component places upon these decision factors. The study utilizes an interview-quesionnaire instrument which has been pretested and which is being used in a sample of hospital administrators, purchasing agents, stockroom people, doctors, nurses, and other appropriate people.



Commonly used items for patient-care—it's disposable units versus the reprocessed.

This investigation is supported by a research grant "Disposable versus Reprocessed Hospital Supplies" from the Division of General Medical Sciences and the Division of Nursing Resources of the United States Public Health Service.

Edited in Retrospect

1937 Georgia Tech's school of Public Health offered a course leading to the degree of Public Health Engineering.

1945 The school of Public Health became the department of Public Health and Biology.

1958 The department of Public Health and Biology was given the name and curriculum changes necessary for that of a department of Applied Biology.

1960 Georgia Tech's department of Applied Biology became a school offering a degree.

And already, several industrial visitors have inquired about the graduation date of the school's candidates.

Even though its activity in public health and biology has been comparatively unknown, Georgia Tech has been active in these fields as early as the September of 1937.

Recently, Tech's research in the fields of bio-engineering and biology has grown in worth and prestige. At the same time, the biology curriculum, greatly expanded and reorganized, is now able to prepare its students for research in the pharmaceutical laboratories, or for future work in medicine or dentistry, or for public health administration and sanitary engineering. At present seven students are enrolled in the school of Applied Biology.

The area of public health at Georgia Tech is one that is all encompassing. It draws from the schools of Civil Engineering, Electrical Engineering, Physics, Chemistry, Biology, and Chemical Engineering. Some of the studies conducted are in the fields of radiation, stream pollution, and smog.

The Reason

★ It has been the purpose of this issue of the Research Engineer to present a brief sketch of some of the fine work done at Georgia Tech and its Engineering Experiment Station in the fields of biology, public health, and medicine. It is hoped that the reader recognizes that Georgia Tech, although primarily an engineering school, has broadened in scope and depth in order to prepare, produce, and progress in the areas of education and research.